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SUPERSONIC PASSENGER AIRPLANE

by

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ABSTRACT: ^{the} This article gives the vital statistics of the new Soviet Supersonic Airliner, the Tupolev TU-144. Some of the problems in designing aircraft and the basic principles of flight are discussed. There is an emphasis on frontal resistance and the wing design. ()

SUPERSONIC PASSENGER AIRPLANE

I. D. Pipko

One of the outstanding events of the traditional 26th International Salon of Aeronautics and Outer Space was the exhibition of the supersonic passenger airplane the TU-144. This craft was created by the force of airplane builders headed by the chief constructor, Twice Hero of Socialist Labor Academician A. N. Tupolev.

Here are the main characteristics of the aircraft: speed of flight, 2,500 kilometers per hour; altitude of flight, up to 20,000 meters; number of passenger places, 121; distance of flight without landing, 6,500 kilometers; normal take-off weight, 130 tons; length of take-off run, 1,900 meters. Behind each one of these figures stands the persistent research of scientists and builders, in connection with a whole series of unbelievably complicated problems in supersonic passenger traffic.

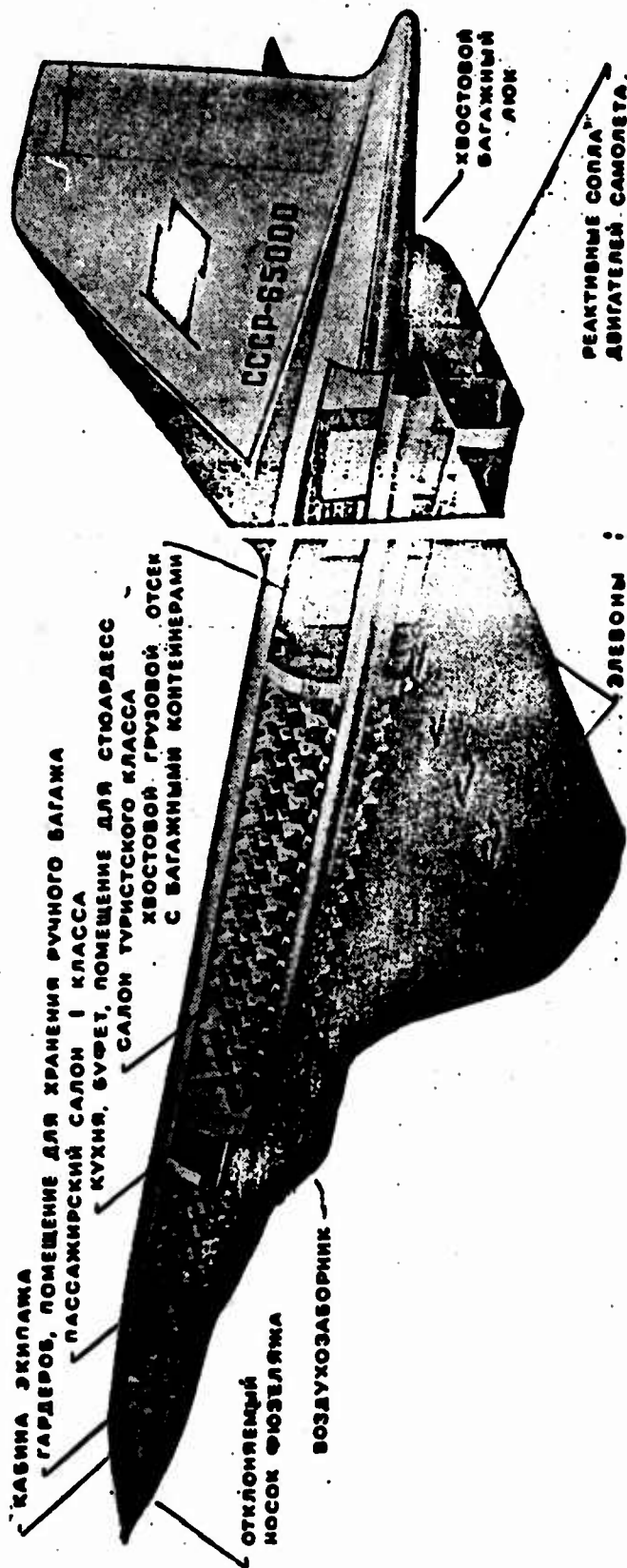
Indeed, simply unbelievably complicated! Notwithstanding the speed records, known to all, which were established by our pilots on aircraft of Soviet production this can seem like exaggeration. But the matter is that the problems of supersonic flight which are encountered in the creation of record machines take on complexity of

two orders higher when one is dealing with passenger airplanes. Not to speak yet of the requirements for maximum safety of flight and high degree of comfort, one has to deal with the problem first of attaining the minimum safety of flight and high degree of comfort, one has to deal with the problem first of attaining the minimum cost of operation. The creating of a supersonic passenger airplane the cost of operation of which should not be higher than that for modern subsonic liners was the goal that the constructors of the TU-144 set for themselves right from the start. This requirement in very great measure determined the whole appearance of the machine to be created.

"The main thing which our aerodynamicists were striving to attain in developing the project of the aircraft," thus spoke Andrey Nikolayevich Tupolev, "was, with all other conditions remaining equal, to obtain the minimum frontal resistance. The greater the frontal resistance of the aircraft is, the more powerful and the heavier the engines will have to be, to assure the required speed of flight. In this situation there is a corresponding increase in the consumption of fuel and the necessary reserve that has to be carried on the airplane for a flight over a given distance. On the other hand the lowering of the frontal resistance without increasing the flying weight of the airplane makes it possible, just through the economy in fuel, to take on a bigger payload, and this means that the cost of transporting a passenger or a kilogram of freight will be less."



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Sketch showing arrangement of the supersonic passenger airplane the TU-144.

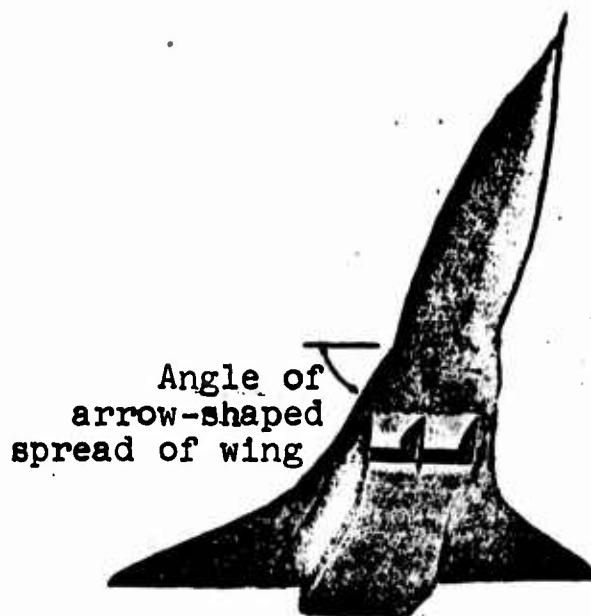
Working in sketch:

Tilttable
fuselage
nose (left)
Air intake
(left)

Crew's cabin

Wardrobe, space for storing hand baggage
Passenger cabin, first class
Kitchen, buffet, accommodation for stewardesses
Cabin for tourist-class passengers
Tail freight section with baggage containers
Ailerons (below)
Tail baggage hatch (right)
Jet nozzles of the aircraft's engines

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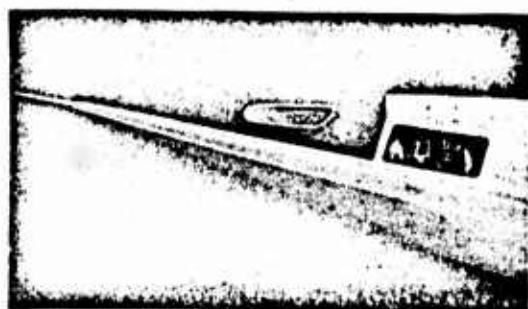
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Model of the airplane TU-144.

The perfection of the aerodynamics is a distinguishing feature of all the machines created under the guidance of A. N. Tupolev. The "Tupolev" craft have remained his top traditions and this time in the case of the TU-144 the frontal resistance is less than that of any other supersonic airplane. In the first place, what strikes a person in looking at the model of the supersonic liner, is the absence of the well-known horizontal tail group. In the case of subsonic craft it assures the so-called longitudinal stability. But in the case of supersonics the longitudinal stability even without this is quite great. So the constructors of the TU-144 gave up the tail group transferring its controlling function to the so-called ailerons — control units "notched" into the wing, representing an assembly of ailerons and elevators. Thus the first economy was attained in the weight of the construction and in the frontal resistance — the first, but not the main one.

The main "element" of any airplane is considered to be the wing. It keeps the airplane in the air, but at the same time, unfortunately, it creates a great deal of frontal resistance. In order to reduce

this "part" the constructors of the TU-144 made the wing of the airplane extraordinarily thin. But the frontal resistance of the wing in supersonic flight depends not only on its thickness but also on its form and design. The greater the sweepback of the wing — the angle at which its leading edge "meets" the oncoming air — the less the resistance. From this point of view the ideal variant would be a wing in the form of a narrow triangle. But here there arises the question of the lifting force — it depends on the length of the wing, or speaking roughly, on its sweep. This is especially important in the case of the subsonic speeds at which the supersonic airplanes perform such important operations as taking off, climbing, and descending before landing.



Outer appearance of tiltable fuselage nose and the arrangement of the crew cabin behind it.

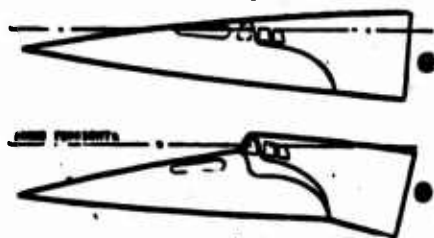


Wardrobe and compartment for hand luggage located at the entrance door.

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And one thing more, the constructors of the TU-144 had to take into account a no less serious obstacle in developing the form of the wing in a plane. In order to reduce the noise in the passenger cabins from the four powerful engines of the aircraft they located the latter almost at the very tail of the fuselage and together with the engines they "shifted" also the center of gravity of the airplane towards the tail. And now if the constructors were to give the wing

the form of a narrow triangle, that would mean that the center of pressure, point of application of the equilibrizing lifting force, would be removed too far away from the center of gravity. In this situation the lifting force and the force of the weight would impart a great revolving moment, to offset which one would have to use very powerful control elements. Thus to the need for increasing the span of the wings there was added another requirement — the maximum approach of the center of pressure to the center of gravity of the airplane. And as a result of the optimum, most favorable solution after numerous attempts there was born the wing of the TU-144 — the wing of complicated form with the arrowlike quality of its shape changing along its sweep. It makes possible the obtaining of a minimum frontal resistance at high speeds, the preserving of the necessary lifting force, and the assuring of the required stability in all forms of operation in flight with a minimum area of the controlling surfaces.



Scheme of arranging the tiltable nose of the fuselage: 1 — position of the nose in horizontal flight; observation of the space in front of the airplane in this case is done by the pilot through the elongated windows in the nose; 2 — the position of the nose in take-off and landing; the pushing down of the nose opens up a view ahead through the window of the crew cabin, which was closed before.

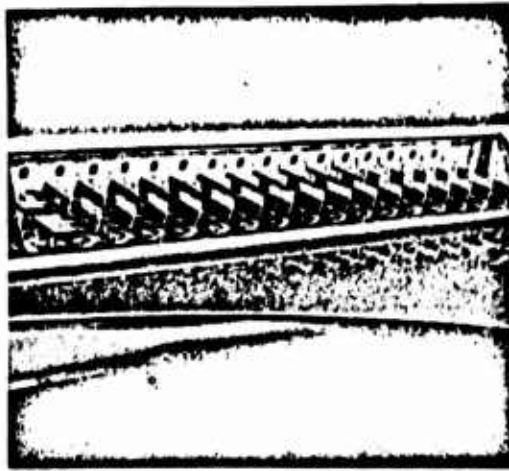
On the model TU-144 there is still another detail which even with stretching a point, one cannot call insignificant. This is the air intake. It is a duct running under the fuselage. It is just on it, that there depends the effective working of the power plant of the supersonic lines. It is known that the characteristics of the engines depend to a great extent on the pressure in their combustion chambers. Here a serious problem arises — the maximum use of the great energy of the oncoming flow of air — to change it with the aid of a carefully selected air intake into increased pressure in the combustion chambers. There is still one complication connected with the air intake. It should operate equally well at cruising speed and when it is braking the speed before landing.

A complicated picture is presented by the flow of the air around a supersonic airplane. Each protruding part of the aircraft — nose of the fuselage, leading edge of the wing, tail group — all these form the so-called jumps in density. These regions of the air with the increased density and pressure interact with each other cutting down, in so doing a great part of the energy of the oncoming flow. This is why the constructors of the TU-144 came to extend the channel of the air intake almost to the nose of the fuselage. But at the same time the creators of the airplane tried to solve this problem with a minimum of losses.



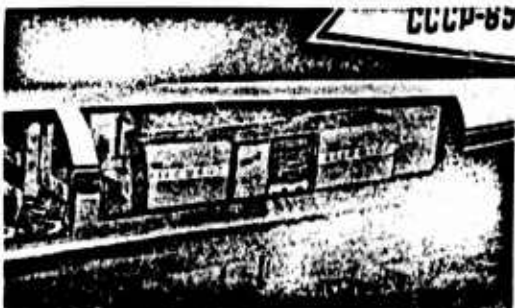
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Nose passenger cabin of the first class.

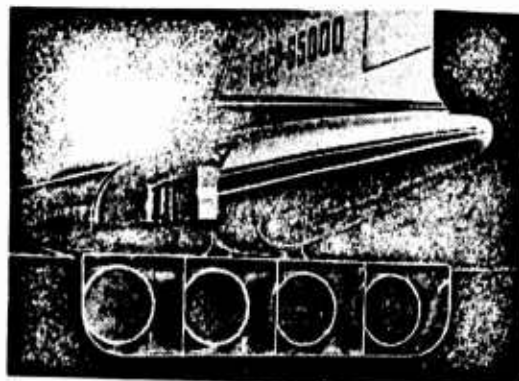


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Main passenger cabin of the tourist class.



Tail baggage section of the airplane with containers, one of which is shown without the side wall.



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Tail part of the airplane with vertical tail group and jet nozzles of the engines located on the trailing edge of the wing.

First of all they united the air intake with the fuselage. In this way the weight of the construction and the frontal resistance came out less than is the case where the engines are located in nacelles under the wings. The biggest thing of all is that the absence on the wings of these "under-structures" in the form of engine nacelles has sharply improved their aerodynamic characteristics. A great deal of labor had to be devoted by the constructors in order to get the dimensions of the air intake down to the minimum. In supersonic flight when the oncoming flow of air enters the "collector" with great speed it is necessary for the engines that the amount of air can be supplied to them through a comparatively not too great

input section, but at subsonic speeds such a section will not be sufficient. The slower the speed of the flow the greater should be the channel by which the air comes to the engines. And then in order to solve this contradictory problem, preserving the minimum dimensions of the air intake, the constructors made it controllable. The lower flaps of the multi-operational air intake of the TU-144 can turn around. Controlled automatically, they at high speeds, reduce the input section to the minimum; and as the speed slows down, they drop down opening to the "quietly moving" air free access.

And finally the fuselage of the airplane — a long sharp-pointed cigar — has smooth outlines in which even the headlight of the pilot's cabin is tapered. Only two narrow slots, reminding one of the eyes of a fanciful fish enable the pilots to see what is happening ahead. But this is only in horizontal flight when the necessity for seeing ahead is taken care of by locators and navigational equipment on the aircraft. And in landing, when the pilots have to see the ground just as much as possible, the nose part of the fuselage is tilted down, opening the front window which is hidden inside, which it is as convenient to see through as through the windshield of an automobile.

In regard to the crew of the airplane, in the nose cabin there are only three seats — two for pilots and one for the flight engineer. On the airplane there is no navigator. His place is taken by an automatic complex of navigation equipment. With the aid of a special device of reflection it, better than the most qualified navigator, will furnish the pilot with all the necessary information.

The greater part of the fuselage of the airplane is taken up by two passenger cabins. Not a small amount of labor went into the

construction in order that there be assured here normal conditions during the course of the whole flight — temperature, moisture, air pressure and composition, all care of. For this it was necessary to provide the airplane with special regulating devices of an artificial climate, which would clean the air, restore its composition and moisture and then return it again to the airplane.

To the passengers of the "air fleet" the advantages of the supersonic airplane appear always in the same way — on account of it the time of the journey is shortened. But to the pilots in this question there is one more important aspect. The supersonic speeds of the flight upon the way to a kind of "higher productivity of the labor" — the greater the speed of the airplane the greater the number of trips it can accomplish during one and the same amount of time. In this connection each extra minute of the airplane's remaining on the ground is converted into a serious loss. Remembering this, the constructors of the TU-144 gave their attention to secondary operations such as loading the baggage. For ordinary subsonic aircraft it usually takes up a considerable amount of time. But on the TU-144 this process requires altogether only a few minutes — the baggage, mail, and freight beforehand are packed into 9 special containers, and when the airplane arrives at the airport these containers with the aid of an automatic system of loading provided on the airplane, are rapidly lifted aboard and take their places in the tail section of the fuselage.

Such is the TU-144, an airplane one could talk about for a long time, because each detail, each assembly of the completed supersonic liner constitutes a serious problem, the solution of which has been prepared by the whole history of our aviation science, by all the experience of our airplane builders.

"The creation of supersonic passenger airplanes," says Andrey Nikolayevich Tupolev in concluding his talk, "is only the first step on the road to the appearance of new generations of air transportation. This problem is exceedingly complicated. And it will be solved by the efforts of the whole country."